costly machine-work. As a record of experience up to date, Mr. Warren's paper will have a permanent value.

The remaining papers on the list are of a miscellaneous character, but all of considerable interest. Mr. Heck described a "Mechanical Method of Finding the Stability of a Vessel," by means of a simple model. This is a very ingenious and labour-saving device, likely to prove of great assistance in ordinary ship-yards, where a staff of trained calculators may be wanting. Mr. Stromeyer described a "Strain Indicator" which he has invented. This instrument is extremely simple in its construction: the essential parts consisting of two flat plates between which is inserted a "rolling-pin" of fine steel wire. Relative motion of the two plates causes the rolling-pin to rotate, and its rotation is the means of measuring the strain to which the material is subjected in any portion of a sample or a structure to which the indicator may be attached. If this instrument answers as well as it promises to do, much will be learnt from its indications as to the strains brought upon ships under various conditions and more especially at sea. Such information carefully compiled and collated ought to prove of value in determining the structural arrangements of ships.

Admiral Paris, the venerable Curator of the Naval Museum at the Louvre, long known for his eminence as a scientific naval officer and as an archæologist in shipbuilding, attended the meetings, and contributed an interesting paper on the "Rolling of Ships," exhibiting an instrument designed to represent the relative movements of ships and waves. His reception was deservedly cordial.

Capt. Colomb described, in a well-written paper, some of the more important results of recent measurements of turning powers of ships in the Royal Navy. These trials are now systematised, and much has been learnt from them which will be of value to future naval tactics, as well as useful to shipbuilders in designing rudders and steering-appliances. A novel steering-gear was described by Mr. Maginnis, who also laid before the Institution some valuable autographic information on the obscure subject of the strains brought upon a rudder when it is "put over" to various angles in a ship moving at speed.

Mr. Read's contribution, "On the Strength of Bulkheads" in ships, was seasonable, the recent loss of the *Oregon* having again drawn public attention to the necessity for water-tight subdivisions as a means of safety from foundering. Mr. Read put into a mathematical form the principles which should regulate the construction of bulkheads if they are to successfully withstand the water-pressure which must come upon them when the compartments are "bilged" and sea-water enters. He did not deal with the principles which should govern the disposition of bulkheads; but these principles are well understood, and more generally acted upon now than formerly.

Another paper by Mr. Benjamin described a "Proposed Steam Lifeboat" which had been designed to be practically uncapsizable; and for that purpose, among others, made of a very peculiar form. The only other paper on the list described the improved methods of working anchors and cables devised by the author, Mr. Baxter. This was a paper of a practical and historical character, on a subject of undoubted importance.

From this hasty summary it will be seen that the Institution of Naval Architects maintained at its recent gatherings its old reputation for widely diversified topics of discussion. And it is to be added that the papers as a whole, numerous as they were, were also of more than average merit.

ON THE USE OF MODELS FOR INSTRUCTION IN THE MAGNETISM OF IRON SHIPS

THE deviations of the compass produced by the iron used in the construction of wooden ships was a source of considerable perplexity to the navigators of the last and early part of the present centuries; and no sooner were these difficulties fairly overcome than the building of ships entirely of iron commenced.

With the introduction of iron ships, prolonged investigations into their magnetism and the resulting deviations of the compass on board were undertaken by some of the most eminent philosophers and mathematicians of the day, the subject being still one which occupies the attention of many observers, from the increased use of iron in the equipment, as well as construction, of the hulls and decks. These investigations were much facilitated by the increased knowledge of the earth's magnetism, which received such notable additions from magnetic surveys made by travellers on land and navigators at sea during the years 1819–45.

Moreover, as time rolled on, these observations were embodied in trustworthy graphic representations of the declination or variation, the dip or inclination, and the horizontal force, which have done such good service in the work of obtaining a clear understanding of the cause of the magnetism of iron ships, and the changes to which such magnetism is liable when the vessel's position is altered either geographically or in respect to the magnetic meridian.

It is not here intended to enter into any historical *résumé* of the names of the several investigators in this branch of science, nor of the results which each obtained, but to indicate at once where the physicist and mathematician may find the theory and examples of its application; also, how the practical results of this elegant theory may, by the use of models, be made intelligible and available to the seaman and other inquirers who have neither the time nor the opportunity for abstruse studies requiring considerable mathematical knowledge.

The text-book which is now generally accepted in all countries is the "Admiralty Manual for the Deviations of the Compass," in Appendix No. 1 of which will be found the three fundamental equations of Poisson, which form the whole theory of the deviations of the compass, and the expressions of these equations "in terms of the quantities which are usually given and required," written by the late Archibald Smith, M.A., F.R.S.

The whole of the action of the soft iron of a ship is represented in these equations by the parameters a, b, c, d, e, f, g, h, k, and in a model by nine soft iron rods fixed in definite positions, distinguished by the same letters.

The effects of the magnetism of the hard iron of the ship are represented in these equations by the parameters P, Q, R, and in the model by two permanent magnets held horizontally in definite positions, and a third permanent magnet held vertically under the compass.

One of the most important contributions to magnetical science as regards iron ships was made by Sir George Airy (late Astronomer-Royal) in a paper published in the *Phil. Trans.* Royal Society for 1839. After making a series of experiments in certain iron-built ships, he discussed the results mathematically with the purpose of discovering a correction for the deviation of the compass. He concluded his paper with the announcement of his invention of the system of correction by magnets and soft iron, which is universally practised in the present day, always with advantage, and often as a matter of necessity in ships of certain types, where to find a suitable place even for the standard compass is a matter of no small difficulty. This system of correction, coupled with the analysis described in the "Admiralty Compass Manual," provides the means of correcting a compass even in position on the 'tween decks of our armour-plated ships of war.

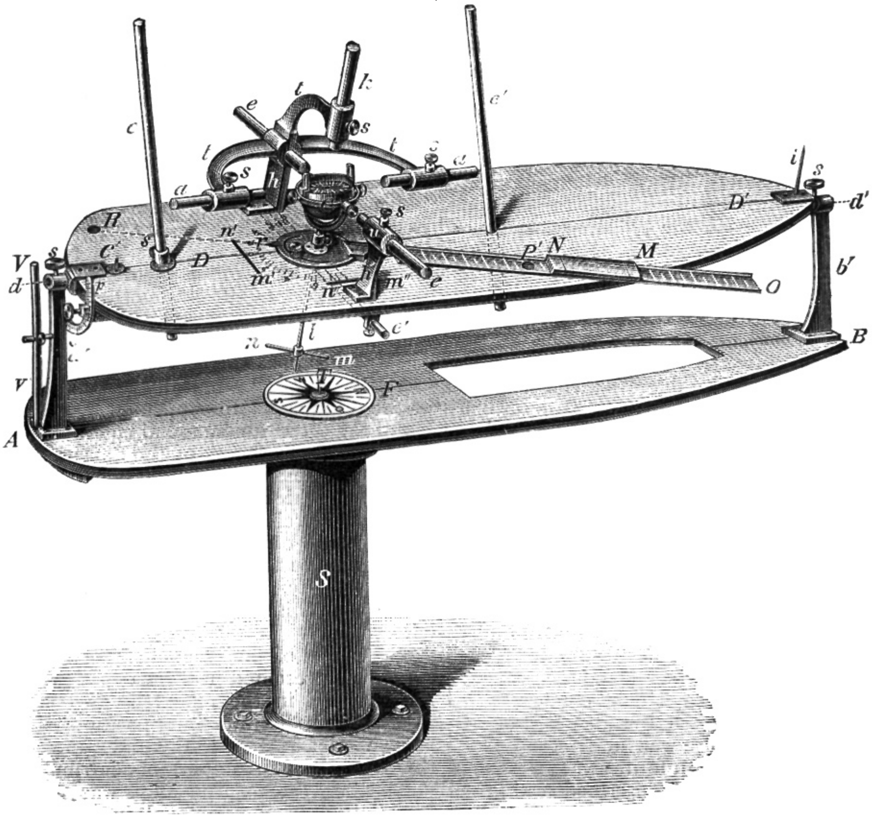
With these preliminary remarks, the description of some different forms of models will be given, and their uses for instruction in the magnetism of iron ships considered.

One of the first of these instructive models was that constructed for Sir George Airy, and used during his lectures to illustrate his method of correction of the deviations of the compass. It consisted of a model of the wooden hull of a vessel. In the centre of the deck a compass was mounted, disturbing magnets and pieces of soft iron being concealed underneath it, producing semicircular and quadrantal deviations as in an iron ship. These deviations were then corrected by placing the model ship with its bow alternately on the north and south magnetic points, when the compass was made to indicate the same directions by means of transverse magnets on the deck; and then on the east and west points magnetic, the correction of the semicircular deviation being completed by longitudinal magnets on the deck. Lastly, with the model placed in a north-east and south-west direction magnetic, scrolls of soft iron were placed on either side of the compass—an imaginary line transverse to the model passing horizontally through the centre of the scrolls and compass-card—until the compass pointed correctly.

Of more recent models there are three which are of an instructive character: one designed by Dr. Neumayer of the German Naval Observatory at Hamburg; the second in England by an official of the Board of Trade; and the third, which is the most complete both for experiments and purposes of instruction, by the United States Navy Department.

The accompanying woodcut on the scale of one-twentieth of the original model is taken from Paper No. 2 of the *Archiv der Deutschen Seewarte*, VI. Jahrgang, 1883, where an account of the experiments to be made with it is given in full detail. The following is a description of the several parts shown.

S is a pillar fixed in the floor of the room, upon which pivots the wooden board A B, with the line of its central axis marked. At the point T, a compass-card is fixed to S, with its north and south points adjustable in the magnetic meridian.



Supported by the two brass uprights $a'b'$, is the second board in the form of a ship's deck pivoting at dd', so that it can be inclined sideways, as when a ship inclines under pressure of sail or when rolling, but kept horizontal as required by the screws ss. An arc, op, marked to degrees, shows the angle of inclination. A gimballed compass, C, with sight vanes, is mounted on the deck, and when the lubber's point and the pin i are in line, as seen through the vanes, the compass support is secured by the clamping-screw. O P′ is a graduated arm revolving round the base of the compass stand, grooved to receive a bar-magnet, and with a pointer, r, showing the number of degrees the arm has been turned in azimuth. h and h' are brass bearers for carrying the rods of soft iron used in disturbing or correcting the compass, with screws, s, for clamping the rods at any required distance.

The model, as described thus far, is entirely free from any magnetic body external to the compass, and may, by means of the latter, be placed with its marked axis in the magnetic meridian, the compass card at T being fixed in that direction for future reference. The means for producing the disturbing forces on the compass similar to those found in iron ships are these. M N is a magnet, which may be so adjusted in the groove that, by moving the arm O P′ in azimuth, semicircular deviation of any desired form may be produced. In the figure the magnet M N is placed to produce the semicircular deviation of a ship built with her head north-north-west, and the resulting south (or blue) pole is found in the point R. The soft iron rod V v in its vertical position represents the stern-post of a ship, producing that part of the semicircular deviation in compasses placed near it, which

changes as the ship moves into fresh magnetic latitudes. $c\,c'$ are soft iron rods, intended to represent iron masts.

Quadrantal deviation of the form generally observed is produced by the soft iron rod e', extending from side to side under the deck D D′ like a deck beam, the rods $a\,a$ also conspiring with e' in increasing the quadrantal deviation. That part of the heeling error caused by the magnetism of the hard iron of a ship is produced by a small vertical magnet in the position of the rod l when removed; that from soft iron by the vertical soft iron rod k and the horizontal rod e'.

The compass C having been disturbed by magnetic forces of the usual type in an iron ship, may now be corrected: $m''\,n''$ is a magnet with its north or marked end, n'', towards the stern of the model, and near enough to the compass to correct the deviation on the east and west points: $m'\,n'$ is a second magnet with its north or marked end, n', towards the port side, correcting the deviation on the north and south points. Or the whole semicircular deviation may be corrected by one magnet, $m\,n$, placed exactly in the direction of R, n being the marked or north end. The quadrantal deviation is corrected by the rods $e\,e$. The heeling error caused by e' is also nearly corrected by $e\,e$, and that caused by the sum of the effects of k and the vertical magnet under the compass by another vertical magnet with the opposite pole uppermost.

Thus it will be seen that any component part of the whole deviation usually found at the standard compass of an iron ship may be produced in the model and the corresponding corrector provided.

The portable model adopted by the Board of Trade has a compass mounted on a ship's deck, as in the figure; but the deck, which rests on a central metal support, revolves round a pivot in the centre of a fixed board, an arrangement for inclining the model being provided.

The disturbing magnets and soft iron are arranged thus. For producing the semicircular deviation due to the hard iron of a ship thin magnets are placed as required in any of the grooves cut in the deck radiating from the centre of the compass, so that deviations due to any direction of the ship's head whilst building may be produced. For that part of the semicircular deviation due to soft iron a vertical soft iron bar is fixed in the central longitudinal line of the deck and near the stern. For the quadrantal deviation hollow cylinders of soft iron are placed under the deck similar to the rod e' of the figure. For the heeling error due to hard iron a magnet is placed vertically under the compass.

The correctors are magnets placed on the deck as $m'n'$, $m''n''$ in the figure, and soft iron spheres—on brass brackets which may be turned in azimuth round the compass—instead of the rods $e\,e$; a Flinder's or vertical soft iron bar before the compass; a vertical magnet under the centre of the compass to correct the heeling error.

This model is exceedingly well adapted for instruction and examination in the causes of the deviations generally found at standard compass positions in the mercantile navy, and the method of correction adopted in that service.

There remains now only the model made for the Bureau of Navigation of the United States Navy Department to be noticed. It consists of a miniature vessel of which the stem, keel, and stern-post are of bronze cast in one piece, with three wooden decks supported by bronze screws. This model, called the *Scoresby*, is pivoted at the stern by a socket in the floor, with a bronze wheel fitted under the bow, so as to be easily turned round in azimuth. The disturbing magnetic forces are produced by magnets and hollow wrought-iron tubes of soft iron, whilst wrought-iron plates can be attached to the sides of the vessel.

The *Scoresby* was designed with the object of proving by experiment the mathematical theory already noticed. Experiments were consequently made as to the effects of hammering the plates of the model with the bow in different directions, a magnetic survey being made after the hammering to determine the polarity in different sections, and its degree of permanency or otherwise. The model was next swung both when upright and inclined, for the deviations of the compass produced by a magnet or soft iron tube representing each parameter singly, combinations being made afterwards as desired. These experimental results proved satisfactorily the correctness of the mathematical theory.

This general description of the *Scoresby* will serve to show that the Americans have taken considerable pains in making valuable experiments in proof of theory, and for instruction to the seaman. Before parting with her, however, a quotation from the American professional paper on the subject of the *Scoresby* seems worthy of a place, as sounding a fresh warning note to those who ruthlessly distribute iron *ad libitum* and in any form round the position of a ship's standard or guiding compass.

"Compensation of large deviations by means of magnets is at the best but a remedy for an ailment; better not sow the seeds of the disease."

The three models just described have been selected as being the most modern specimens of these useful aids to knowledge, but there are others for the instruction of officers in the Royal Navy which have been in use for some years past. It will be gratifying to the many who take interest in maritime affairs to note the increasing anxiety for the spread of a sound knowledge of the principles of the magnetism of iron ships and the deviations of their compasses which the construction of these models manifests.

NOTES

THE total number of candidates for election into the Royal Society this year is sixty-two. Of these the following fifteen have been selected by the Council to be recommended to the Society for election; the voting will take place on June 4:—Shelford Bidwell, M.A., W. Colenso, F.L.S., H. B. Dixon, F.C.S., E. R. Festing, Major-Gen. R.E., Prof. A. R. Forsyth, M.A., Prof. A. H. Green, M.A., Prof. Victor Horsley, F.R.C.S., T. R. Lewis, M.B., R. Meldola, F.R.A.S., P. H. Pye-Smith, M.D., H. C. Russell, B.A., Prof. W. C. Unwin, B.Sc., R. Warington, F.C.S., Capt. W. J. L. Wharton, F.R.A.S., and H. Wilde.

THE following are the probable arrangements for the Friday evening meetings of the Royal Institution after Easter:—May 7, Mr. Frederick Siemens, "Dissociation"; May 14, Prof. John Millar Thomson, F.C.S., "Suspended Crystallisation"; May 21, Sir John Lubbock, Bart., M.P., F.R.S., "The Forms of Seedlings: the Causes to which they are due"; May 28, Prof. Oliver Lodge, D.Sc., "Electrical Deposition of Dust and Smoke"; June 4, Walter H. Gaskell, M.D., F.R.S., "The Sympathetic Nervous System"; June 11, Prof. Dewar, M.A., F.R.S.

THE editor of the *Sidereal Messenger* (U.S.) writes in his April number:—"We are glad to learn from private advices that a small observatory will soon be fitted up with the necessary instruments for continuous solar and local magnetic observation, in which daily solar photographs of the sun will form an important part of the work done by the observers. We are not aware that work of this kind is now anywhere systematically undertaken in the United States."

THE Congress of French Sociétés Savantes will take place as usual at the Sorbonne, and the final ceremony under the chairmanship of M. Goblet, the present Minister of Public Instruction. It is